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ABSTRACT

This study seeks answers for the questions: How do young children express wonder and curiosity in the classroom culture? and How do teachers of young children foster wonder and curiosity? Teacher behavior has an effect on students, fostering students' curiosity and wonder or the opposite. This study also explores the efficiency of an observation instrument used to assess the state of wonder and curiosity. In young children, wonder is highly inherited and for adults in certain professions like scientists and artists, highly valued and cultivated. (Contains 47 references.) (YDS)

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Fostering Wonder in Young Children:

Baseline Study of Two First Grade Classrooms

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> **wonder (wun' der)**, 1. to think or speculate curiously and sometimes doubtfully... 2. to be filled with awe; marvel... 3. to speculate curiously; be curious to know... 4. to feel wonder... 5. a cause of surprise, astonishment, or admiration... 6. a feeling of amazement, puzzled interest, or reverent admiration...
>
> **curiosity (kyoor' e os' i te)**, *pl* . ñties. 1. the desire to learn or know about anything; inquisitiveness. 2. a curious, rare, or novel thing. 3. a strange, curious, or interesting quality.

(Webster's College Dictionary, 1997)

Introduction

The scientific community recognizes that lifelong scientific literacy is based on values and attitudes formed in early childhood. "Highest priority should be given to encouraging the curiosity about the world that children bring to school (American Association for the Advancement of Science, 1993, p. 285). Permeating throughout the early childhood literature is the theme of "keeping wonder alive" in young children (Doris, 1992). In contrast, the literature regarding curiosity in older elementary children through adulthood concentrates on how to generate curiosity. (Berlyne, 1960; 1966; Lowenstein, 1994; Reeve, 1996). The dichotomy of focus in the literature itself suggests a demise of wonder at some point in the elementary school. Questions driving this study are: (1) How do young children express wonder and curiosity in the classroom culture?; and (2) How do teachers of young children foster wonder and curiosity?

To understand what teachers do to foster curiosity and wonder in young children, one must first be able to recognize expressions of wonder and curiosity when they occur. Next, it is necessary to identify teacher behavior that offers opportunities for wonder and curiosity in students. An observation instrument providing a lens for viewing wonder and curiosity was composed, based on a review of the related literature.

The purpose of this study is to explore how functional this instrument is in assessing the state of wonder and curiosity in the classroom culture. It should be noted that attending to wonderment in pedagogy is only one of the multitudinous facets in the kaleidoscope of teaching. The intent of this baseline pilot study is to judge the usefulness of the observation instrument while I ascertain how two first grade teachers are nurturing wonder in their students. Both teachers are interested in learning how to enhance their own practice toward encouraging wonder and curiosity in their students.

It is hoped that by observing two science-enthusiast teachers through this lens, the instrument will be improved and offer usefulness in two ways. First, such an instrument could serve as a baseline-study point for those who are interested in providing further opportunities for wonder and curiosity in the classroom culture. In this regard, using the instrument for a subsequent assessment after intervention could provide a means for judging the efficacy of intervention. Secondly, the instrument holds potential as a reflective tool for teachers who are interested in nurturing wonder and curiosity in their students.

Significance of the Study

The sense of wonder so inherent in young children is highly valued, even cultivated, within certain adult professions. Science is such a profession. In schools, science provides a safe haven for nurturing wonder and curiosity amidst a culture clamoring for accountability in teaching, standardization in curriculum, and heightened test scores in schools.

Wonder is not limited to scientists, however. Wonder is also valued among artists as they interpret the world, poets as they bring new light to the ordinary, and philosophers as they question what ëis.í Aristotle, for example, considered wonder the beginning point of philosophy (Matthews, 1980).

Further, what we now call mythology is attributed to wonder, curiosity, and the attempt to explain the unknown (Campbell, 1972; Flowers, 1988). Upheld by educators (Doris, 1991; Duckworth, 1996; Eisner, 1991), wonder and curiosity are the heart of motivation theory (Berlyne, 1960, 1966; Lowenstein, 1994; Reeve, 1996), the root of invention, and the spirit of making sense of the world (Carson, 1956; Gardner, 1991).

How Children Express Wonder and Curiosity

(For definitions and examples, please see Table 1 in the Appendix.)

Those who work with young children frequently observe their expressions of wonder and curiosity through various modalities. The most obvious expressions of wonder and curiosity are found through children's questions (Chukovsky, 1963; Doris, 1991; Duckworth, 1996; Isaacs, 1930/1966; Matthews, 1980) and observations (Doris, 1991). Often times, guesses or hypotheses accompany their observations (Chukovsky, 1963; Doris, 1991; Duckworth, 1996; Isaacs, 1930/1966; Matthews, 1980). These particular modes of expressing wonder are most typically observed in children's use of language--a language of wonder, expressed by "I wonder," "How," the unceasing "Why," or expressions of paradox.

Expression of wonder and curiosity is not limited to oral language. Further vehicles for expressing wonder and curiosity are art (Chukovsky, 1963, Edwards, Gandini, & Forman, 1998), imaginative play (Isaacs, 1930/1966; Latham, 1996), stories (Engle, 1995; Yolen, 1981), myth (Latham, 1996), and conceptual play in language (Chukovsky, 1963; Latham, 1996; Matthews, 1980; Perry & Rivkin, 1992). Behavior, exhibited through engagement or excitement may further indicate a sense of wonder.

Howard Gardner (1991) believes that the process of questioning, observing, and hypothesis making are providing children with understanding. Through this means, children are building theories about the physical world, mind, matter, and life, among other things. Imagination is the glue that connects wonder with observed phenomena through theory building (Chukovsky, 1963; Eisner, 1991; Matthews, 1980).

Children, working through associative thinking patterns (Bukatko & Daehler, 1995; Chukovsky, 1963), make meaning of the world through theory building. Typically associating the known with the unknown, children create engaging suppositions, premises, and questions. Chukovsky (1963) beautifully illustrates how children think imaginatively with associations by offering examples of children's quotes. One such quote from a young child is "Make a fire, Daddy, so that it can fly up into the sky and make the sun and the stars" (p. 22). Recognizing the expressions of wonder that are characterized by associative expressions of the known with the unknown--a language of wonder, is a key factor in fostering wonder and curiosity in young children.

Since wonder and curiosity are integral to motivation, engagement, and interest during later school years through adulthood, it is highly relevant that we begin to recognize, appreciate, and foster young children's expressions of wonder. What happens in elementary schools to cause wonder and curiosity to disappear in the school setting? Pedagogical practice fostering wonder and curiosity in young students should be viewed and analyzed.

How Teachers Foster Wonder and Curiosity

(For definitions and examples, please see Table 2 in the Appendix.)

When teachers value wonder and curiosity, they encourage it (Doris, 1991; Duckworth, 1996) and create wonder-filled environments (Latham, 1996). Further, teachers will value their students' questions, interests, interpretations (Bullock, 1992; Perry & Rivkin, 1992; Peturson, 1995) and symbolization processes (Chukovsky, Latham, 1996; Perry & Rivkin, 1992). Latham (1996) indicates that believing in children creates a culture that encourages curiosity and wonder. Caring about children's interests and needs nurtures wonder and curiosity (Duckworth, 1996; Eisner, 1991; Noddings, 1984; Perry & Rivkin, 1992). Respect (Eisner, 1991; Noddings, 1984; Ross, 1997) is a crucial aspect of the wonder-supported classroom culture.

Planned lessons and experiences with children's interests in the forefront (Doris, 1991; Duckworth, 1996; Hawkins, 1969; Williams, 1997) provide another means of supporting wonder and curiosity. Subsequently, by allowing children to take time for exploring interests and questions (Doris, 1991, 1992; Perry and Rivkin, 1992) and "messing about" (Hawkins, 1969), wonder and curiosity are nurtured. After exploration and learning, there should always be a time for sharing, pulling together, dialogue (Hawkins, 1969; Perry & Rivkin, 1992), and reflection (Latham, 1996).

Additionally, the following have been identified as means for fostering children's wonder in the classroom culture: carefully selected children's literature (Chukovsky, 1963; Huus, 1978; Yolen, 1981); modeling wonder (Latham, 1996); recognizing the value of not knowing (Latham, 1996; Matthews, 1980, 1984; Chukovsky, 1963; Edwards, Gandini, & Forman, 1998); posing questions, allowing guessing with feedback (Lowenstein, 1994; Reeve, 1996); predicting; and sequencing events with an unknown outcome (Reeve, 1996).

In summary, teachers who foster wonder and curiosity in students do so through certain behaviors and practices. Likewise, young children express wonder and curiosity through exhibiting particular behaviors, using the language of wonder through speaking, writing, and illustrating. An observation instrument, created from the review of the literature and employed in a

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baseline study of two science-enthusiast teachers, provides a lens for viewing classroom interaction. Through this view, the classroom culture is seen from a wonder and curiosity perspective.

Methods

Using a nonparticipant role as researcher, I observed two first grade classrooms doing science. This study incorporated past surveys of teachers to determine attitudes toward how they view science and wonder. After the last observation, I interviewed the selected teachers for further data. Data were collected by audiotape, field notes, and student artifacts.

The purpose of this baseline study is to assess the functionality and usefulness of the observation instrument. By discerning how children express wonder and curiosity in the school setting, data are put in the context of the literature. Further, by collecting baseline data, thereby viewing pedagogy under a pair of wonder-and-curiosity spectacles, I may assess the efficacy of a future intervention with these teachers. Finally, using the checklist as a lens provides a quick overview of the state of wonder in two first grade science classes.

Participants

Two first grade classrooms located in different school districts in Colorado were purposefully selected for this baseline study. Playing into the selection process was the potential for rich data, noted through three distinctive areas: selected teachers hold a shared interest in science; teachers expressed a commitment to wonder; and the teacher surveys indicate pedagogical differences between the teachers.

The teachers in this project hold similar interests and goals in teaching science. Both have expressed a commitment toward nurturing wonder in students. Interestingly, neither teacher holds special certification in science teaching, yet both immerse themselves in science projects for personal development, attend science conferences whenever possible, and enjoy science-related vacations. Further, although the two teachers differed in how they approached science teaching, the basic structures of their science periods were the same. Both teachers began with bringing students together by relating the current topic with prior knowledge and relevant class experiences. Followed by the science experience, each teacher engaged in a form of direct teaching at some point during this time, but in different styles. Each ended with a summation or reflection on the experience.

Teacher A holds a Master's Degree in early childhood and elementary education. She has taught for 21 years in most elementary grade levels and several additional specialist areas. Observation and interview data indicate that her approach to teaching science includes well-planned, highly organized, and structured lessons. Teaching through questions, "hands-on" experiences and providing explicit directions are also characteristic of Teacher A's practice.

> *"I believe that students construct their learning and. . . I guide that through questioning techniques. It has to involve the student building that learning and that translates also to hands on. . . . I believe in the process of learning having to involve kids in as many intelligences and as many modes as possible" (Teacher A).*

Teacher B, on the other hand, is a first-year teacher holding a Bachelor's Degree from the University of Colorado at Denver. Observation and interview data indicate that she typically offers a common experience for learning and provokes students' questioning, hypotheses making, and inquiry within the context of the experience. Experimentation based on students' questions characterizes her science periods. Opportunities for exploring materials are offered and encouraged.

> *"Science is not a subject that is exclusive to the last hour of the day when we bring out the science 'toys.' I see science infiltrate my whole day in the way that questions are formed, the point of view taken or the reasoning that happens every minute of every day. [The most important component of authentic science inquiry is] providing freedom for kids to explore" (Teacher B).*

Classroom A is located in an upper-middle Socio Economic Scale (SES) neighborhood. The school is housed in a building that is less than four years old. Students in Classroom A have access to three computers in their classroom, a permanent television set hung from the ceiling, and a state-of-the-art media center. Twenty-four students, (20 white, 3 Hispanic, and 1 Asian) compose the population of this class. Teacher A has a student teacher in her room at times. She helped with classroom management during one of the observed science periods.

Classroom B is located in a low SES neighborhood. The school, which is a Title I School with 95% of the population on free or reduced lunch, is housed in a building approximately 20 years old. Students in Classroom B have access to one computer in their classroom. Twenty-four students (5 Hispanic and 19 white) make up the classroom population. During one observed science class, a teacher aide assisted Teacher B.

Findings

Using the developed lens, a series of observations were made to test the tools in the field. Through initial results, strengths and

limitations of the lens emerged. Strengths were noted through categorizing and quantifying verbal expressions of wonder. The following are examples gleaned from the lens.

Observations and artifacts gathered from Classroom A indicate that children are expressing wonder and curiosity through verbal observations and theory making. When children make observations, hypotheses, and theories, they often relate something known with the unknown. In these cases, their theories reflect cognitive dissonance. Children display that they are still trying to make sense of the world they do not know. Examples of imaginative language and associative thinking displaying wonder in Classroom A are:

> *"I see a little thingy inside the house" (observing Abraham Lincoln inside the Lincoln Memorial on a penny).*
>
> *"She [the fish] thinks this classroom is [pause]. She thinks we are all in a big aquarium with a clock."*
>
> *"She's [the fish] eating rain food."*

In Class B, expressions of wonder and curiosity were often in the form of verbal "wonder" questions. Examples of Classroom B's verbal expressions are:

> *When a student is asked why he is making small fins, he replies "I wondered if it would go higher with smaller fins."*
>
> *When launching pop-bottle rockets, one student said, "I wonder how high it will go."*

Further indications of wonder were noticed on the chart paper in the group area. This artifact holds a collective record of children's ideas about "What we know about the moon" and, in another column, "I wonder..." The wonder questions are as follows:

> *...if the moon is made of cheese.*
>
> *...if you touch the moon will it move?*
>
> *...is the moon bumpy?*

Strengths of the lens were noted by categorizing and quantifying teachers' verbal expressions or practice eliciting the expressions in children. Perhaps most interesting are teacher responses to wonder. The following examples provide a view into the functionality of the lens in qualifying and quantifying pedagogy with regard to wonder.

Teacher A provokes theories by asking "why" and "what" questions. Although all of the "what" questions serve as an information-gathering function, the aforementioned imaginative play in language occurred after Teacher A posed "What is she doing?" eliciting the "rain food" answer. A "why" question prompted the "classroom as an aquarium" metaphor.

Additionally, Teacher A validates each of her students' responses by listening attentively, often repeating the statement, sometimes elaborating on them.

> *"She thinks this classroom is a big aquarium with a clock inside of it" repeated Teacher A, stopping the rhythm of the class by sitting thoughtfully for a moment as though mulling over his important words.*
>
> *"The food is raining down and she's eating like Cloudy with a Chance of Meatballs " said Teacher A.*

Teacher B provokes "wonder" questions in her students in several ways. First, Teacher B models her own wonderings:

> *"I wonder how high this rocket will go!"*
>
> *"I wonder if we should try [launching a rocket] without a cone and see how it goes."*
>
> *"I wonder where you can get that."*

Next, Teacher B asks questions, which appear to spark additional wonder questions in her students. She asks "what," and "how," and "why." Specifically, through Teacher B's questioning, students provide information, predictions, and theories, with a few questions of their own thrown in. Teacher A was observed asking:

> *"Why the small fins?"*
>
> *"What do you think will happen?"*
>
> *"What's happening?"*

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"How can we solve the problem?"

Teacher B offered opportunities for exploring wonder questions.

> *"We'll have to watch, then, to see what happens with smaller fins." (in response to a student-posed wonder question.)*

Then, prior to the experimentation phase, several days later (after the building the rockets):

> *"Michael, did you say you wondered if it would wiggle before lifting off? Let's be sure and watch to see what will happen."*

In addition, Teacher B validated and scaffolded children's observations, predictions, and theories by engaging in dialogue.

> *"The cone has a hole in it, on the top. Missy, what do you think could be a problem with that?" asked Teacher B. Missy replies "The air could be a problem." Teacher B repeats Missy's hypothesis in a thoughtful manner and asks why she thought it could be a problem. Missy thinks and says she doesn't know. John says "Air, if it comes in, it might push the water down." Teacher B repeats John's prediction and says "Think about that, John" and shows everyone a fully assembled bottle rocket. It is evident that the bottom of the bottle is actually the top of the rocket and air will not touch the water inside. John smiles and says "The air makes it go down." Teacher B says "So if the rocket goes up, the air might come in the hole and push the rocket down? It will be interesting to see if that could slow the rockets down."*

Finally, Teacher B provided opportunities for free exploration of materials. The following, drawn from field notes, depicts a free exploration or "messing about in science" deemed so necessary by Hawkins (1969).

> *One boy is shaking the water in his bottle, watching it intensely. Another is pouring the water out of his bottle and concentrating on how the water flows as the bottle is held at different angles. A third child is controlling the faucet, watching the water run as the knob is turned in different ways. Each is intrigued in the exploration. Classmates, in the mean time, cut fins, make cones, and glue them on their rockets. When these three boys finished their water explorations, other children take their place--sometimes up to five children at the sink--doing similar things, while Teacher B assists individual students as needed and keeps a watchful eye over all.*

Discussion

The purpose of this pilot study of the instrument and the baseline study of the classroom culture was to view classrooms from a wonder and curiosity perspective. This study offered a view through a wonder and curiosity perspective, providing insight into two questions: (1) How do children express wonder in the context of schooling? and (2) How are teachers of young children nurturing wonder and curiosity in school settings?

In this baseline study, the lens gleaned from the literature provides a fleeting glance of children's expressions of wonder as well as pedagogical practice. Although further data are needed to draw conclusions about correlations between pedagogy (such as traditional and facilitative) and expressions of wonder in classrooms, several general themes emerged from the analysis of the teacher-student interaction.

First, the lens suggests that providing opportunities for students to make observations or theories procures opportunities for expression of wonder. Teacher A offered opportunities for students to report observations by asking "what" questions when she taught. She further offered written and artistic opportunities in student science journals (completed during previous science periods). Teacher B also elicited observations, theories, and predictions from her students through questioning, science journals (again, science journals were completed during previous science periods).

Secondly, the lens indicates that appropriate teacher response may encourage the risk-taking necessary for hypothesis and theory making, another place for a display of wonder. Both teachers who were observed in this baseline study validated each of their studentsí contributions by always listening in an active manner. Sometimes the listening was followed by repeating the studentís statement; at other times elaboration followed.

Next, the lens shows that positive teacher response may encourage students to continue to question. Chukovsky (1963) indicates that answering childrenís questions is a skill and an art. Teachers should satisfy and foster curiosity "so that. . . these questions may become more and more interesting" (p. 32). Chukovsky admonishes adults who provide answers (without contemplation) to childrenís creative endeavors to understand the world. He offers an example of a childís view of posing questions to adults "Iím a why-er, you are a because-er" (p. 31). Simply answering a question does not foster wonder. Teacher B exhibited mastery in this area by her response to student-posed questions. Once, she answered, "I donít know, letís watch to find out," then carried out her suggestion.

Additionally, data filtered through the lens suggests that modeling wonder questions and offering opportunities to explore studentsí own wonder questions may encourage students to wonder in classroom settings. Teacher B exemplified the wondering process as part of her pedagogy.

Offering time for "messing about with science" (Hawkins, 1969) provides students with opportunities to exhibit wonder. Teacher Bís students displayed their enraptured and persistent explorations of the flow, pressure, speed, and properties of water in the context of bottle-rocket making. In this regard, students who care about something that is interesting to them are allowed a time for free exploration of materials and interests. Teacher B, who allow "messing about" time in science, is implicitly validating her students' desires to wonder, explore, and understand.

Finally, data gleaned through the lens perspective indicates that providing opportunities for children to explore their own questions in the context of the lesson offered expressions of wonder. When students are allowed to follow their own wonderings, the implicit curriculum is one of ultimate trust, promoting self efficacy and autonomy. Teacher B offered her students an opportunity for collaboration when she asked "How can I solve this problem?" She validated students' decision-making attempts and self-efficacy when she offered "Good ideas, to wash your bottles out. Good ideas." By asking "Why small fins?" followed by the student answer "I wondered if it would go as higher with smaller fins," Teacher B's response of "We'll have to watch then, to see what happens with the smaller fins" brought forth a subsequent experiment and classroom analysis of the event. The higher purpose of carrying forth the process of scientific inquiry through observation, hypothesis making, experimentation, reflection, and theory building were carried forth in the context of wonder.

Limitations

This study is an effort at piloting an observation instrument while providing base line information on wonder and curiosity in the classroom culture in two first grade classrooms. Although it holds strengths, particularly in the rich context of two science-enthusiast teachers and their classrooms, it is not without limits. Limitations exist in the realm of typical limitations found in qualitative research, as well as validity and reliability issues.

The role of nonparticipant observer holds the advantage of concentrating on the observation, being particularly perceptive to interactions. The disadvantage of this means of observation, however, is its "obtrusive" nature (Krathwohl, 1998, p. 252). Teachers and students may exhibit "on stage" behavior, unless observed over time. This particular study encompasses two observations per teacher, offering a limitation in this area.

The subjective nature of the study provides additional limitations. The interpretive baggage I bring into the study colors my definitions, observations, and analysis. Aligning with constructivists who view educating children as a process-oriented endeavor rather than a product-directed enterprise, my own lens is tinted with value for the unique and imaginative.

The observation instrument itself holds neither validity nor reliability, providing further limitations to the conclusion and results of this study. Experience with the baseline study suggests that definitions are still in need of modification and refinement. Future studies over a longer period of time, including additional observers for inter-rater reliability, may improve the instrument and lend credence to the results. Additional studies could also off-set limitations included with the nonparticipant observer role.

Appendix

Table 1

How do children express wonder and curiosity?

Indicators	Definition	Supported by:
Questions	A display of paradox or puzzlement, not knowing. Asking "why," "how," "I wonder," "what," and so on.	Chukovsky, 1963; Doris, 1991; Duckworth, 1996; Isaacs, 1930/1966; Matthews, 1980
Observations	Statements holding questions or expressions of dissonance or mystery. Utterances of excitement through tone, inflection, and facial expression denote wonder.	Doris, 1991
Hypothesis making	A proposal, prediction, or guess about what might happen. Noted by questions such as "I wonder if it willÖ," stated discrepancies, or associations of the known coupled with the unknown evidenced by use of analogy, metaphor or mistaken associations and approximations, for examples.	Chukovsky, 1963; Doris, 1991; Duckworth, 1996; Isaacs, 1930/1966; Matthews, 1980
Theories	A stated interpretation, opinion, or proposal explaining phenomena.	Gardner, 1991; Eisner, 1991; Matthews, 1980
Art	A symbolic means for expressing predictions, theories, and wonder. Discrepancies between the "real" and the "hypothesized or theorized" can be noted in childrenís artwork as they illustrate understandings. Noted when the known is artistically associated with the unknown. Art can be a vehicle toward "drawing out the thoughts of children" (Forman, 1998). Verbalization of the symbolic is a necessary component in understanding children's observations, hypotheses, and theories.	Chukovsky, 1963; Edwards, Gandini, & Forman, 1998
Imaginative play	Children test their wonderment in play. Play provides a safe environment for acting out the mysteries of life. One example of imaginative play may be observed when children build high towers with blocks, pretending to reach the sun, but testing the reality of balance and gravity.	Isaacs, 1930/1966; Latham, 1996
Stories	Children create stories that offer clues about where they are in their understandings. Engle (1995) suggests that children's stories are directly linked to their experiences. The symbolism of their stories often disguises the hypothesis or theory expressed. Through recording children's conversations, Engle identifies children's stories with either her teaching or a home experience. Wonder expressed in stories include contradictory statements, associations of known with the unknown, analogies, metaphor, theories, and hypotheses.	Engle, 1995; Yolen, 1981
Myths	Just as Joseph Campbell (Flowers, 1985) indicates that humankind invented stories to explain the unknown--how we got here, why, and for what purpose, so do children create myths about things they do not understand. For example, one child suggested that God creates the snow when he wants the world to be quiet.	Lathem, 1996
Conceptual play in language	Making up new words such as "thingy" to represent an unidentifiable object or concept.	Chukovsky, 1963;

Table 2

How do teachers foster wonder and curiosity in the classroom culture?

Providing opportunities for wonder to emerge:	Definition	Supported by:
• Create a wonder-filled physical environment	"A place for science" (Doris, 1991) is part of the classroom environment. Objects for observing, tools for experimentation, materials for recording data, and books for exploring interests are examples of items found in the place for science. Additional items or surprises are part of the environment, such as the pussy willow in the Spring or the mysterious gall that has suddenly "broken out" into insects.	Doris, 1991; Latham, 1996
• Create a wonder-filled classroom culture		
1. Trust	Reliance on the ability and integrity of others. The confidence that students will make appropriate decisions. Indicators of trust in the classroom culture include teachers encouraging students to make decisions on their own.	Newton, 1997
2. Respect	Listening, paying attention, asking questions for clarifications, and responding. Teachers model active listening and require it in their students.	Eisner, 1991; Hawkins, 1963; Noddings, 1984; Ross, 1997
3. Approximations valued	Mistakes are part of the learning process, they are indicators of the zone of proximal development. An example of teachers holding value for approximations is allowing students to make predictions and testing them, scaffolding or facilitating the next level of questions upon the student's realization of the fallacy of thought.	
4. Expectation	Demonstrating that children have the capacity to create and learn, noted by statements of support and providing opportunities for children to create.	Latham, 1996
• Providing opportunities for children's questions	Allowing and encouraging students to ask questions. Teachers validate children's questions by listening, responding appropriately, or recording them.	Bullock, 1992; Harvey, 1998; Perry & Rivkin, 1992; Peturson, 1995.
• Provide opportunities for observations and recording data	Allowing time and resources for individual and group observations. Rather than "conform" to a class observation with only one correct answer (which has its value in teaching observation skills), students are given an opportunity to explore, observe, and record on their own, socially with peers, and artistically on an individual or group basis, for examples.	Doris, 1991

• Encourage hypothesis making	Individual or divergent thinking in guessing or predicting is allowed and valued. The responsiveness of teacher interaction is noted through active listening, questioning, repeating, or elaborating on the child's hypothesis.	Edwards, Gandini, & Forman, 1998, Lowenstein, 1994; Reeve, 1996
• Encourage children's theory making	Interpretations of what happened are supported through first, allowing children to make their own theories. Secondly, teachers validate individual theory making by actively listening, questioning, repeating the theory, or elaborating.	Chukovsky, 1963; Edwards, Gandini, & Forman, 1998; Gardner, 1991
• Honor multi-modal symbolic expressions of wonder and curiosity	Students are provided with opportunities to express themselves through writing, speaking, art, math, drama, dance, physical movement, music... Through the many "languages" of children (Maliguzzi, 1993), wonder is exhibited in multiple modalities and takes-on various formats, but is usually recognized by a display of paradox or conflict.	Chukovsky, 1963; Edwards, Gandini, & Forman, 1998; Eisner, 1994; Gardner, 1983;
• Encourage children to pursue interests	Allowing and supporting exploration of wonder questions and personal interests. Providing a support structure and opportunities for exploring children's wonder questions in the context of learning or during a free exploration time.	Bullock, 1992; Duckworth, 1996; Noddings, 1984; Perry & Rivkin, 1992; Peturson, 1995.
• Planning lessons with children's interest in the forefront:		Doris, 1991; Duckworth, 1996; Hawkins, 1969; Williams, 1997
1. Authentic and developmentally appropriate	Science lesson is relevant to children and holds mystery and/or captures the interest of children (noted by engagement). Teaching the child at developmental level, rather than teaching subject to the child.	Bredekamp & Copple, 1997
2. Inquiry supported	Investigation as opposed to teacher-directed worksheets or conformity toward one right answer or way of interpreting.	Ross, 1997
3. Allowing time for exploring interests and wonder questions	Wonder questions are incorporated into the lesson or students are allowed opportunities to explore them freely.	Doris, 1991, 1992; Gandini, Forman, & Edwards, 1998; Perry & Rivkin, 1992; Reeve, 1996
4. Tinkering or "messing about in science"		Hawkins, 1969
5. Sharing or pulling together	Students need time to freely explore materials.	
6. Reflection	Coming together as a class to dialogue about events, offering a time for sharing different observations and interpretations.	Hawkins, 1969; Perry & Rivkin, 1992
	Talking about what happened and putting it in the context of other experiences, observations, and theories. Teachers may support the reflection process through documentation of the science process through quotes from children, recording wonder questions, photographs and student artifacts.	Latham, 1996

• Dialogue	Listening to each other, an exchange of ideas.	Hawkins, 1969; Perry & Rivkin, 1992
• Recognizing the value of not knowing	Teacher allows a wonder question or a problem to go unsolved, piquing the interest of her students (as opposed to always having an answer). It should be noted that at times, a ready answer piques curiosity (Doris, 1991).	Chukovsky, 1963; Edwards, Gandini, & Forman, 1998; Latham, 1996; Matthews, 1980, 1984;
• Carefully selected children's literature	Accuracy in content, appealing story, holds interest, well written. Children's fiction should include paradox, mystery, creativity, and imagination.	Chukovsky, 1963; Harvey, 1998; Huus, 1978; Yolen, 1981
• Modeling wonder	Teacher models "I wonder why, what...." questions for students in an authentic manner.	Latham, 1996
• Posing questions, riddles, puzzles	Setting up discrepant events to the interest of the child.	Lowenstein, 1994; Reeve, 1996
• Encourage multiple perspectives and ways of inquiring	Children are offered freedom to provide their own perspective in how the inquiry process was carried forth. For example, if how to measure the class Guinea pig is the concern, children are provided with the opportunity to create their own means for inquiry -- within the guidelines or structure set forth by the teacher. They may be asked to work individually or in groups to answer the question of "How long is Fluffy?" Rulers, links, unifix cubes, etc. may be used. Techniques may vary. But each will record observations, method, and measurement (the structure).	Latham, 1996;
• Careful response	Avoiding simplistic responses to children's questions and observations.	Chukovsky, 1963; Doris, 1991; Duckworth, 1996; Latham, 1996

References

American Association for the Advancement of Science (AAAS). (1993). Benchmarks for science literacy: Project 2061. New York: Oxford University Press.

American Association for the Advancement of Science (AAAS). (1998). Blueprints for reform: Science, mathematics and technology education, project 2061. New York: Oxford University Press.

Beaty, J. (1996). Preschool appropriate practices. Orlando, FL: Harcourt Brace & Company.

Berlyne, D. (1960). Conflict, arousal, and curiosity. New York: McGraw-Hill Book Company.

Berlyne, D. (1966). Curiosity and exploration. Science, 153, 25-33.

Black, S. (1995). How do your children grow? The Executive Educator, 17, 12, 17-20.

Bredekamp, S. , & Copple, C. (Eds.) (1997). Developmentally appropriate practice in early childhood programs, revised edition. Washington, DC: National Association for the Education of Young Children.

Bukatko, D., & Daehler, M. (1995). Child development: A thematic approach. Boston, MA: Houghton Mifflin Company.

Bullock, J. (1992). "Where does electricity live?" Answering the "wonder" questions in the primary grades. Dimensions of Early Childhood, 20, 3, 34-36.

Campbell, J. (1972). Myths to live by. New York: Penguin Group.

Carson, R. (1956). The sense of wonder. New York: Harper & Row Publishers.

Chukovsky, K. (1963). From two to five. Berkeley, CA: University of California Press.

Coles, R. (1984). Forward. In Matthews, G. Dialogues with children. Cambridge, MA: Harvard University Press.

Coles, R. (1990). The spiritual life of children. Boston, MA: Houghton Mifflin Company.

Doris, E. (1991). Doing what scientists do: Children learn to investigate their world. Portsmouth, NH: Heinemann.

Doris, E. (1992). Keeping wonder alive. Holistic Education Review, , 26-31.

Duckworth, E. (1996). The having of wonderful ideas and other essays on teaching and learning: Second edition. New York: Teachers College Press.

Edwards, C., Gandini, L., & Forman, G. (Eds.) (1998). The hundred languages of children: The Reggio Emilia approach--advanced reflections, second edition. Greenwich, CT: Ablex Publishing Corporation.

Eisner, E. (1991). What really counts in schools? Educational Leadership, 48, 5, 10-11, 14-17.

Engle, S. (1995). The stories children tell: Making sense of the narratives of childhood. New York: W. H. Freeman and Company.

Flowers, B. (Ed.) (1988). Joseph Campbell: The power of myth. New York: Doubleday.

Gardner, H. (1991). The unschooled mind. New York: BasicBooks.

Haiman, P. E. (1991). Developing a sense of wonder in young children: There is more to early childhood education than cognitive development. Young Children, 46 (6), 52-53.

Hartjen, R. (1994). Empowering the child: Nurturing the hungry mind. Port Tobacco, MD: Alternative Education Press, Ltd.

Harvey, S. (1998). Nonfiction matters: Reading, writing, and research in grades 3-8. York, ME: Stenhouse Publishers.

Hawkins, D. (1969). Messing about in science: Occasional papers. Newton, MA: Early Childhood Education Study.

Hawkins, D. (1974). The informed vision: Essays on learning and human nature. New York: Agathon Press.

Huss, H. (1978). Building with books. Paper presented at the Annual Meeting of the International Reading Association, 23rd, Houston, TX, May 1-5. (ERIC Document Reproduction Service No. ED 165 108)

Isaacs, S. (1930/1966). Intellectual growth in young children. New York: Schocken Books.

Latham, G. (1996). Fostering and preserving wonderment. Australian Journal of Early Childhood, 21,1, 12-15.

Lowenstein, G. (1994). The psychology of curiosity: A review and reinterpretation. Psychological Bulletin, 116, 1, 75-98.

Malaguzzi, L. (1993). For an education based on relationships. Young Children, 49,1, 9-12.

Matthews, G. (1984). Dialogues with children. Cambridge, MA: Harvard University Press.

Matthews, G. (1980). Philosophy and the young child. Cambridge, MA: Harvard University Press.

McIntyre, M. (1977). Exploratory play: Development of science concepts. Science and Children, 15, 2, 38-39.

McNay, M. (1985). Science: All the wonder things. Childhood Education, 61, 5, 375-78.

National Research Council. (1996). National science education standards. Washington, DC: National Academy Press.

Newton, K. (1997). The search for wonder: A continuing mission. In Duckworth, E. (Ed.). Teacher to teacher: Learning from each other. New York: Teachers College Press.

Noddings, N. (1984). Caring: A feminine approach to ethics and moral education. Berkeley, CA: University of California Press.

Noddings, N. (1992). The Challenge to Care in Schools: An Alternative Approach to Education. New York: Teachers College Press.

O'Sullivan, C. Y., Jerry, L., Ballator, N., and Herr, F. (1997). NAEP 1996 science state report for department of defense domestic dependent elementary and secondary schools, grade 4. Washington, DC: National Center for Education Statistics.

Perry, G., & Rivkin, M. (1992). Teachers and science. Young Children, 9-16.

Peturson, R. (1995). Science: Reaching for Rainbows, K-2. Bothell, WA: Wright Group Publishing, Inc.

Reeve, J. (1996). Motivating others: Nurturing inner motivational resources. Boston, MA: Allyn and Bacon.

Roche, R. (1977). The child and science: wondering, exploring, growing. Washington, DC: Association for Childhood Education International.

Ross, M. E. (1997). Scientists at play. Science and Children, 34 (8), 35-38. Williams, K. (1997). "What do you wonder?" Involving children in curriculum planning. Young Children, 52, 6, 78-81.

Yolen, J. (1981). Touch magic: Fantasy, faerie and folklore in the literature of childhood. New York: Philomel Book